Chapter G4: Value of I&E Losses at the Seabrook and Pilgrim Facilities Based on Benefits Transfer Techniques

This chapter presents the results of EPA's evaluation of the economic losses associated with I&E at the Seabrook and Pilgrim facilities using benefits transfer techniques. Section G4-1 provides an overview of the valuation approach, Section G4-2 discusses the value of losses to recreational fisheries, Section G4-3 discusses the value of commercial fishery losses, Section G4-4 discusses values of forage losses, Section G4-5 discusses nonuse values, and Section G4-6 summarizes benefits transfer results.

CHAPTER CONTENTS

G4-1 Overview of Valuation Approach

I&E at Seabrook and Pilgrim affect recreational and commercial fisheries as well as forage species that contribute to the biomass of fishery species. EPA evaluated all these species groups to capture the total economic impact of I&E at Seabrook and Pilgrim.

Recreational fishery impacts are based on benefits transfer methods, applying results from nonmarket valuation studies. Commercial fishery impacts are based on commodity prices for the individual species. The economic value of forage species losses is determined by estimating the replacement cost of these fish if they were to be restocked with hatchery fish, and by considering the foregone biomass production of forage fish resulting from I&E losses and the consequential foregone production of commercial and recreational species that use the forage species as a prey base. All of these methods are explained in further detail in Chapters A5 and A9 of this document.

Many of the I&E-impacted fish species at Seabrook and Pilgrim are harvested both recreationally and commercially. To avoid double-counting the economic impacts of I&E on these species, EPA determined the proportion of total species landings attributable to recreational and commercial fishing, and applied this proportion to the impacted fishery catch. For example, if 30 percent of the landed numbers of one species are harvested commercially at a site, then 30 percent of the estimated catch of I&E-impacted fish are assigned to the increase in commercial landings. The remaining 70 percent of the estimated total landed number of I&E-impacted adult equivalents are assigned to the recreational landings.

The National Marine Fisheries Service (NMFS) provides both recreational and commercial fishery landings data by state. To determine what proportions of total landings per state occur in the recreational or commercial fishery, EPA summed the landings data for the recreational and commercial fishery, and then divided by each category to get the corresponding percentage. The percentages applied in this analysis are presented in Table G4-1.

Table G4-1: Percentages of Total Impacts in the Recreational and Commercial Fisheries of Selected Species at Seabrook and Pilgrim Facilities

Fish Species	Percent Impacts to Recreational Fishery	Percent Impacts to Commercial Fishery
Alewife	0	100
American plaice	0	100
Atlantic cod	6	94
Atlantic herring	0	100
Atlantic mackerel	62	38
Atlantic menhaden	0	100
Atlantic silverside	0	100
Blueback herring	100	0
Bluefish	50	50
Butterfish	7	93
Cunner	87	13
Little skate	0	100
Pollock	2	98
Red hake	0	100
Scup	45	55
Searobin	100	0
Striped bass	86	14
Tautog	63	37
White perch	89	11
Windowpane	3	97
Winter flounder	70	30

Fri Feb 08 10:11:00 MST 2002 ; TableA:Percentages of total impacts occurring to the commercial and recreational fisheries of selected species; Plant: seabrook.90.98 ; Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableA.Perc.of total.impacts.seabrook.90.98.csv

As discussed in Chapter A5 of Part A of this document, the yield estimates presented in Chapter G3 represent the total pounds of foregone yield for both the commercial and recreational catch combined. For the economic valuation discussed in this chapter, Table G4-1 partitions total yield between commercial and recreational fisheries based on the landings in each fishery. Because the economic evaluation of recreational yield is based on numbers of fish rather than pounds, foregone recreational yield was converted to numbers of fish. This conversion was based on the average weight of harvestable fish of each species. Tables G4-2 and G4-3 show these conversions for the Seabrook and Pilgrim impingement data presented in Chapter G3, and Tables G4-4 and G4-5 displays the conversions for entrainment data. Note that the numbers of foregone recreational fish harvested are typically lower than the numbers of age 1 equivalent losses, since the age of harvest of most fish is greater than age 1.

Table G4-2: Summary of Seabrook's Mean Annual Impingement of Fishery Species

Species	Impingement Count (#)	Age 1 Equivalents (#)	Total Catch (#)	Total Yield (lbs)	Commercial Catch (#)	Commercial Yield (lbs)	Recreational Catch (#)	Recreational Yield (lbs)
Alewife	508	679	7	3	7	3	0	0
Atlantic herring	287	334	104	46	104	46	0	0
Blueback herring	50	58	2	0	0	0	2	0
Butterfish	28	38	3	2	3	2	0	0
Cod Atlantic	99	118	20	39	19	36	1	2
Cunner	232	323	7	1	1	0	6	1
Little skate	110	141	37	29	37	29	0	0
Mackerel, Atlantic	2	3	1	0	0	0	0	0
Menhaden, Atlantic	12	14	5	5	5	5	0	0
Pollock	643	707	154	1,038	151	1,017	3	21
Rainbow smelt	701	949	21	7	9	3	12	4
Red hake	1,041	1,333	394	238	394	238	0	0
Scup	3	4	0	1	0	0	0	0
Searobin	4	5	0	0	0	0	0	0
Silverside, Atlantic	1,040	1,871	58	1	58	1	0	0
Striped bass	1	1	0	1	0	0	0	1
Tautog	7	7	2	8	1	3	1	5
White perch	1	1	0	0	0	0	0	0
Windowpane	664	797	295	59	286	57	9	2
Winter flounder	1,032	1,136	286	358	86	107	200	251
Total	6,465	8,519	1,396	1,837	1,160	1,548	236	289

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Table G4-3: Summary of Pilgrim's Mean Annual Impingement of Fishery Species

Species	Impingement Count (#)	Age 1 Equivalents (#)	Total Catch (#)	Total Yield (lbs)	Commercial Catch (#)	Commercial Yield (lbs)	Recreational Catch (#)	Recreational Yield (lbs)
Alewife	3,250	4,343	43	22	43	22	0	0
Atlantic cod	252	302	52	99	49	93	3	2
Atlantic mackerel	2	3	1	0	0	0	0	0
Blueback herring	612	703	15	5	0	0	15	3
Bluefish	2	2	1	1	0	1	0	1
Butterfish	297	399	29	19	27	18	2	1
Cunner	295	411	9	2	1	0	7	1
Herring, Atlantic	7,593	8,836	2,743	1,225	2,743	1,225	0	0
Little skate	61	78	20	16	20	16	0	0
Menhaden, Atlantic	5,048	6,165	2,011	2,111	2,011	2,111	0	0
Pollock	30	33	7	48	7	47	0	0
Rainbow smelt	5,118	6,929	154	52	63	21	91	14
Red hake	178	229	68	41	68	41	0	0
Scup	97	114	13	21	7	12	6	4
Searobin	56	69	6	3	0	0	6	2
Silverside, Atlantic	11,587	20,842	651	8	651	8	0	0
Striped bass	6	9	1	13	0	2	1	5
Tautog	183	201	56	223	21	83	35	54
White perch	55	73	0	0	0	0	0	1
Windowpane	236	284	105	21	102	20	3	0
Winter flounder	1,039	1,144	287	361	86	108	201	98
Total	35,997	51,168	6,270	4,292	5,900	3,827	371	186

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Table G4-4: Summary of Seabrook's Mean Annual Entrainment of Fishery Species

Species	Entrainment Count (#)	Age 1 Equivalents (#)	Total Catch (#)	Total Yield (lbs)	Commercial Catch (#)	Commercial Yield (lbs)	Recreational Catch (#)	Recreational Yield (lbs)
Alewife	0	0	0	0	0	0	0	0
Atlantic herring	4,767,333	13,900	4,315	1,927	4,315	1,927	0	0
Bluefish	11,111	1	0	0	0	0	0	0
Butterfish	55,556	27	2	1	2	1	0	0
Cod, Atlantic	10,007,778	2,330	402	763	378	717	24	46
Cunner	35,403,667	184,427	3,840	832	499	108	3,341	724
Little skate	0	0	0	0	0	0	0	0
Mackerel, Atlantic	245,390,667	1,058	207	146	79	56	128	91
Menhaden, Atlantic	301,556	19	6	6	6	6	0	0
Plaice, American	27,435,889	1,167	230	134	230	134	0	0
Pollock	660,390	7	2	10	2	10	0	0
Rainbow smelt	69,778	7,730	171	58	70	24	101	34
Red hake	93,151,889	362	107	65	107	65	0	0
Searobin	11,111	227	18	11	0	0	18	11
Tautog	128,444	7	2	8	1	3	1	5
Windowpane	25,726,667	10,317	3,818	761	3,703	738	115	23
Winter flounder	244,035,113	78,046	19,615	24,602	5,885	7,381	13,731	17,221
Commercial and Recreational Species Total	687,156,949	299,623	32,736	29,323	15,276	11,168	17,460	18,155

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Table G4-5: Summary of Pilgrim's Mean Annual Entrainment of Fishery Species

Species	Entrainment Count (#)	Age 1 Equivalents (#)	Total Catch (#)	Total Yield (lbs)	Commercial Catch (#)	Commercial Yield (lbs)	Recreational Catch (#)	Recreational Yield (lbs)
Alewife	323,435	0	0	0	0	0	0	0
Atlantic cod	6,291,173	2,138	369	700	347	658	22	32
Atlantic mackerel	1,034,964,861	6,659	1,303	921	495	350	808	439
Cunner	2,714,603,689	993,500	20,688	4,481	2,689	582	17,999	3,449
Herring, Atlantic	6,942,590	20,243	6,284	2,806	6,284	2,806	0	0
Menhaden, Atlantic	81,926,445	8,105	2,644	2,776	2,644	2,776	0	0
Plaice, American	11,260,136	221	43	25	43	25	0	0
Pollock	42,751,473	492	107	723	105	708	2	2
Rainbow smelt	10,112,547	1,323,137	29,309	9,900	12,017	4,059	17,292	674
Red hake	31,075,325	1,545	457	275	457	275	0	0
Searobin	1,970,043	3,698	300	184	0	0	300	64
Silverside, Atlantic	1,435,668	5,087	159	2	159	2	0	0
Tautog	7,512,870	875	242	972	90	360	153	212
Windowpane	83,547,445	17,258	6,387	1,272	6,195	1,234	192	13
Winter flounder	30,900,375	209,571	52,672	66,062	15,802	19,819	36,870	40,908
Total	4,065,618,075	2,592,529	120,963	91,099	47,326	33,654	73,638	45,794

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G4-2 Economic Value of Average Annual Losses to Recreational Fisheries Resulting From I&E at Seabrook and Pilgrim Facilities

G4-2.1 Economic Values of Recreational Fishery Losses from the Consumer Surplus Literature

There is a large literature that provides willingness-to-pay (WTP) values for increases in recreational catch rates. These increases in value are benefits to the anglers, and are often referred to by economists as "consumer surplus." In applying this literature to value I&E impacts, EPA focused on changes in consumer surplus per additional fish caught.

When using values from the existing literature as proxies for the value of a trip or fish at a site not studied, it is important to select values for similar areas and species. Table G4-6 gives a summary of several studies that are closest to the Cape Cod and Ipswich Bay fisheries in the vicinity of the Seabrook and Pilgrim stations.

Table G4-6: Selected Valuation Studies for Estimating Changes in Catch Rates

Authors	Study Location and Year	Item Valued	Value Estimate ($2000)[a]	
McConnell and Strand (1994)	Mid- and south Atlantic coast, anglers targeting specific species, 1988	Catch rate increase of 1 fish per trip for NY[b]	NY flatfish NY small game fish NY bottom fish	$5.35 $9.54 $2.54
Tudor et al. (2002)[c]	Delaware Estuary, 2001	Catch rate increase of 1 fish per trip	DE weakfish DE striped bass DE bluefish DE Flounder	$11.50 $18.14 $3.94 $3.92
Hicks et al. (1999)	Mid-Atlantic coast, 1994	Catch rate increase of 1 fish per trip, from historical catch rates at all sites, for NH and MA	NH and MA flatfish NH and MA small game fish NH and MA bottom fish	$5.29 $3.69 $2.43

[a] The recreational WTP values reported in subsequent tables are incorrectly stated as being slightly less than the values reported here. This indicates that the recreational losses in those tables are moderately understated.
[b] Value was reported as "two month value per angler for a half fish catch increase per trip." From 1996 National Survey of Fishing, Hunting and Wildlife-Associated Recreation (U.S. DOI, 1997), the average saltwater angler takes 1.5 trips in a 2 month period. Therefore, to convert to a "1 fish per trip" value, EPA divided the 2 month value by 1.5 trips and then multiplied it by 2, assuming the value of a fish was linear.
[c] See chapter B5 of this document. These values were not applied in the analysis, but remain listed here for comparison.

McConnell and Strand (1994) estimated fishery values for the mid- and south Atlantic states using data from the NMFS Survey. They created a random utility model of fishing behavior for nine states, the northernmost being New York. In this model they specified four categories of fish: small gamefish (e.g., striped bass), flatfish (e.g., flounder), bottomfish (e.g., weakfish, spot, Atlantic croaker, perch), and big gamefish (e.g., shark). For each fish category, they estimated per angler values for access to marine waters and for an increase in catch rates.

Tudor et al. (2002; see chapter B5 of this document) applied a random utility model (RUM) to the recreational fishery impacts associated with I&E in the Delaware Estuary. The methods, data, and results of the Tudor et al. (2002; see chapter B5 of this document) study are discussed in greater detail in Chapters A10 and B5 of this document. These values were not applied in the Seabrook-Pilgrim analysis because the McConnell and Strand (1994) study is more geographically precise, but they are listed here as a basis for comparison.

Hicks et al. (1999) used the same method as McConnell and Strand (1994) but estimated values for a day of fishing and an increase in catch rates for the Atlantic states from Virginia north to Maine. Their estimates were generally lower than those of McConnell and Strand (1994) and may serve as a lower bound for the values of fish.

G4-2.2 Economic Values of Recreational Fishery Losses at Seabrook and Pilgrim

EPA estimated the average annual economic value of Seabrook and Pilgrim I&E impacts to recreational fisheries using the I&E estimates presented in Tables G4-2 through G4-5 and the economic values presented in Table G4-6. Because none of the studies in Table G4-6 considered the region around Seabrook and Pilgrim directly, EPA created a lower and upper value

for New Hampshire and Massachusetts for each impacted recreational species, and then calculated a weighted average value based on the proportion of landings from each state. Results are presented in Tables G4-7 through G4-10. The estimated total losses at Seabrook to the recreational fisheries range from $1,100 to $1,300 for impingement per year (Table G4-7), and from $75,000 to $87,200 annually for entrainment (Table G4-8). The estimated losses at Pilgrim range from $1,500 to $2,100 for impingement per year (Table G4-9), and from $287,900 to $408,800 annually for entrainment (Table G4-10).

Table G4-7: Average Annual Impingement of Recreational Fishery Species at Seabrook and Associated Economic Values

Species	Loss to Recreational Catch from Impingement (number of fish)	Recreational Value/Fish		Annual Loss in Recreational Value from Impingement ($2000)	
		Low	High	Low	High
Blueback herring	2	$2.28	$2.73	$5	$6
Butterfish	< 1	$3.75	$8.56	$1	$2
Cod Atlantic	1	$2.28	$2.46	$3	$3
Cunner	6	$2.28	$2.73	$13	$16
Mackerel, Atlantic	< 1	$3.75	$8.56	$1	$3
Pollock	3	$2.28	$2.41	$7	$7
Rainbow smelt	12	$3.75	$8.56	$46	$106
Scup	< 1	$2.28	$2.73	$0	$1
Searobin	< 1	$2.28	$2.56	$1	$1
Striped bass	< 1	$3.75	$8.56	$0	$1
Tautog	1	$2.28	$2.48	$3	$3
Windowpane	9	$4.80	$5.51	$42	$49
Winter flounder	200	$4.80	$5.49	$959	$1,097
Total	236			$1,083	$1,295

Note: Numbers of fish are rounded here but not in calculations.
Fri Feb 08 10:11:06 MST 2002 ; TableB: recreational losses and value for selected species; Plant: seabrook.90.98 ; type: I Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableB.rec.losses.seabrook.90.98.I.csv

Table G4-8: Average Annual Entrainment of Recreational Fishery Species at Seabrook and Associated Economic Values

Species	Loss to Recreational Catch from Entrainment (number of fish)	Recreational Value/Fish		Annual Loss in Recreational Value from Entrainment ($2000)	
		Low	High	Low	High
Bluefish	< 1	$3.75	$8.56	$0	$1
Butterfish	< 1	$3.75	$8.56	$1	$1
Cod Atlantic	24	$2.28	$2.46	$55	$59
Cunner	3,341	$2.28	$2.73	$7,618	$9,121
Mackerel, Atlantic	128	$3.75	$8.56	$481	$1,098
Rainbow smelt	101	$3.75	$8.56	$379	$865
Searobin	18	$2.28	$2.56	$42	$47
Tautog	1	$2.28	$2.48	$3	$3
Windowpane	115	$4.80	$5.51	$550	$631
Winter flounder	13,731	$4.80	$5.49	$65,908	$75,382
Total	17,460			$75,036	$87,209

Note: Numbers of fish are rounded here but not in calculations.
Fri Feb 08 10:11:15 MST 2002 ; TableB: recreational losses and value for selected species; Plant: seabrook.90.98 ; type: E Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableB.rec.losses.seabrook.90.98.E.csv

Table G4-9: Average Annual Impingement of Recreational Fishery Species at Pilgrim and Associated Economic Values

Species	Loss to Recreational Catch from Impingement (number of fish)	Recreational Value/Fish		Annual Loss in Recreational Value from Impingement ($2000)	
		Low	High	Low	High
Atlantic cod	3	$2.28	$2.46	$7	$8
Atlantic mackerel	< 1	$3.75	$8.56	$1	$3
Blueback herring	15	$2.28	$2.73	$33	$40
Bluefish	< 1	$3.75	$8.56	$1	$2
Butterfish	2	$3.75	$8.56	$8	$17
Cunner	7	$2.28	$2.73	$17	$20
Pollock	< 1	$2.28	$2.41	$0	$0
Rainbow smelt	91	$3.75	$8.56	$340	$775
Scup	6	$2.28	$2.73	$14	$17
Searobin	6	$2.28	$2.56	$13	$14
Striped bass	1	$3.75	$8.56	$4	$9
Tautog	35	$2.28	$2.48	$80	$87
Windowpane	3	$4.80	$5.51	$15	$17
Winter flounder	201	$4.80	$5.49	$966	$1,105
Total	371			$1,499	$2,115

Note: Numbers of fish are rounded here but not in calculations.
Thu Feb 07 17:19:25 MST 2002 ; TableB: recreational losses and value for selected species; Plant: pilgrim.74.99 ; type: I Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/TableB.rec.losses.pilgrim.74.99.I.csv

Table G4-10: Average Annual Entrainment of Recreational Fishery Species at Pilgrim and Associated Economic Values.

Species	Loss to Recreational Catch from Entrainment (number of fish)	Recreational Value/Fish		Annual Loss in Recreational Value from Entrainment ($2000)	
		Low	High	Low	High
Atlantic cod	22	$2.28	$2.46	$51	$54
Atlantic mackerel	808	$3.75	$8.56	$3,030	$6,916
Cunner	17,999	$2.28	$2.73	$41,037	$49,136
Pollock	2	$2.28	$2.41	$5	$5
Rainbow smelt	17,292	$3.75	$8.56	$64,847	$148,023
Searobin	300	$2.28	$2.56	$684	$768
Tautog	153	$2.28	$2.48	$348	$378
Windowpane	192	$4.80	$5.51	$920	$1,056
Winter flounder	36,870	$4.80	$5.49	$176,978	$202,418
Total	73,638			$287,897	$408,755

Note: Numbers of fish are rounded here but not in calculations.
Thu Feb 07 17:19:34 MST 2002 ; TableB: recreational losses and value for selected species; Plant: pilgrim.74.99 ; type: E Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/TableB.rec.losses.pilgrim.74.99.E.csv

G4-3 Economic Value of Average Annual Commercial Fishery Losses Resulting From I&E at Seabrook and Pilgrim

Values for commercial fishing losses are relatively straightforward because commercially caught fish are a commodity with a market price (blue mussel are not included in EPA's valuation of commercial fishery losses as discussed in the accompanying box). Losses to commercial catch (pounds) resulting from I&E at Seabrook are presented in Table G4-2 (for impingement) and Table G4-4 (for entrainment). Commercial losses at Pilgrim are presented in Table G4-3 (for impingement) and Table G4-5 (for entrainment). The market value of foregone commercial yield at Seabrook is $978 for impingement per year (Table G4-11), and $11,542 annually for entrainment (Table G4-12). The market value of foregone commercial yield at Pilgrim is $517 for impingement per year (Table G4-13), and $30,787 annually for entrainment (Table G4-14).

Recorded impingement and entrainment of blue mussel at Seabrook and Pilgrim ranges from 2.2 trillion in 1974 to 19.1 trillion in 1975. Corresponding yield ranges from 1.2 to 10.4 billion pounds. Based on a commercial value in some parts of New England of $0.24 per pound, these losses equate to $2.6 billion annually. However, blue mussel in the area around Seabrook and Pilgrim are considered a nuisance species because they clog intake screens (Entergy Nuclear Generation Company, 2000) and compete with commercially desirable species, such as soft shell clam (Mike Hickey, MA Division of Marine Fisheries, personal communication, January 16, 2002). As a result, EPA did not consider blue mussel losses in its benefits analysis.

Table G4-11: Average Annual Impingement of Commercial Fishery Species at Seabrook and Associated Economic Values

Species	Loss to Commercial Catch from Impingement (lb of fish)	Commercial Value (lb of fish)	Annual Loss in Commercial Value from Impingement ($2000)
Alewife	3	$0.17	$1
Atlantic herring	46	$0.05	$2
Butterfish	2	$0.47	$1
Cod Atlantic	36	$0.83	$30
Little skate	29	$0.19	$6
Menhaden, Atlantic	5	$0.04	$0
Pollock	1,017	$0.69	$702
Rainbow smelt	3	$0.20	$1
Red hake	238	$0.22	$52
Silverside, Atlantic	1	$0.54	$0
Tautog	3	$0.64	$2
Windowpane	57	$0.57	$32
Winter flounder	107	$1.38	$148
Total	1,548		$978

Fri Feb 08 10:11:07 MST 2002 ; TableC: commerical losses and value for selected species; Plant: seabrook.90.98 ; type: I Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableC.comm.losses.seabrook.90.98.I.csv

Table G4-12: Average Annual Entrainment of Commercial Fishery Species at Seabrook and Associated Economic Values

Species	Loss to Commercial Catch from Entrainment (lb of fish)	Commercial Value (lb of fish)	Annual Loss in Commercial Value from Entrainment ($2000)
Atlantic herring	1,927	$0.05	$96
Butterfish	1	$0.47	$1
Cod Atlantic	717	$0.83	$595
Cunner	108	$0.37	$40
Mackerel, Atlantic	56	$0.28	$16
Menhaden, Atlantic	6	$0.04	$0
Plaice, American	134	$1.20	$160
Pollock	10	$0.69	$7
Rainbow smelt	24	$0.20	$5
Red hake	65	$0.22	$14
Tautog	3	$0.64	$2
Windowpane	738	$0.57	$421
Winter flounder	7,381	$1.38	$10,185
Total	11,168		$11,542

Fri Feb 08 10:11:16 MST 2002 ; TableC: commerical losses and value for selected species; Plant: seabrook.90.98 ; type: E Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableC.comm.losses.seabrook.90.98.E.csv

Table G4-13: Average Annual Impingement of Commercial Fishery Species at Pilgrim and Associated Economic Values

Species	Loss to Commercial Catch from Impingement (lb of fish)	Commercial Value (lb of fish)	Annual Loss in Commercial Value from Impingement ($2000)
Alewife	22	$0.17	$4
Atlantic cod	93	$0.83	$77
Bluefish	1	$0.25	$0
Butterfish	18	$0.47	$8
Herring, Atlantic	1,225	$0.05	$61
Little skate	16	$0.19	$3
Menhaden, Atlantic	2,111	$0.04	$84
Pollock	47	$0.69	$33
Rainbow smelt	21	$0.20	$4
Red hake	41	$0.22	$9
Scup	12	$1.05	$12
Silverside, Atlantic	8	$0.54	$4
Striped bass	2	$1.50	$3
Tautog	83	$0.64	$53
Windowpane	20	$0.57	$12
Winter flounder	108	$1.38	$149
Total	3,827		$517

Thu Feb 07 17:19:25 MST 2002 ; TableC: commerical losses and value for selected species; Plant: pilgrim.74.99 ; type: I Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/TableC.comm.losses.pilgrim.74.99.I.csv

Table G4-14: Average Annual Entrainment of Commercial Fishery Species at Pilgrim and Associated Economic Values

Species	Loss to Commercial Catch from Entrainment (lb of fish)	Commercial Value (lb of fish)	Annual Loss in Commercial Value from Entrainment ($2000)
Atlantic cod	658	$0.83	$546
Atlantic mackerel	350	$0.28	$98
Cunner	582	$0.37	$216
Herring, Atlantic	2,806	$0.05	$140
Menhaden, Atlantic	2,776	$0.04	$111
Plaice, American	25	$1.20	$30
Pollock	708	$0.69	$489
Rainbow smelt	4,059	$0.20	$812
Red hake	275	$0.22	$61
Silverside, Atlantic	2	$0.54	$1
Tautog	360	$0.64	$230
Windowpane	1,234	$0.57	$703
Winter flounder	19,819	$1.38	$27,350
Total	33,654		$30,787

Thu Feb 07 17:19:34 MST 2002 ; TableC: commerical losses and value for selected species; Plant: pilgrim.74.99 ; type: E Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/TableC.comm.losses.pilgrim.74.99.E.csv

EPA has expressed changes to commercial activity thus far as changes from dockside market prices. However, to determine the total economic impact from changes to the commercial fishery, EPA determined the losses experienced by producers (watermen), wholesalers, retailers, and consumers.

The total social benefits (economic surplus) are greater than the increase in dockside landings, because the increased landings by commercial fishermen contribute to economic surplus in each of a multi-tiered set of markets for commercial fish. The total economic surplus impact thus is valued by examining the multi-tiered markets through which the landed fish are sold, according to the methods and data detailed in Chapter A9.

The first step of the analysis involves a fishery-based assessment of I&E-related changes in commercial landings (pounds of commercial species as sold dockside by commercial harvesters). The results of this dockside landings value step are described above. The next steps then entail tracking the anticipated additional economic surplus generated as the landed fish pass from dockside transactions to other wholesalers, retailers and, ultimately, consumers. The resulting total economic surplus measures include producer surplus to the watermen who harvest the fish, as well as the rents and consumer surplus that accrue to buyers and sellers in the sequence of market transactions that apply in the commercial fishery context.

To estimate producer surplus from the landings values, EPA relied on empirical results from various researchers that can be used to infer producer surplus for watermen based on gross revenues (landings times wholesale price). The economic literature (Huppert, 1990; Rettig and McCarl, 1985) suggests that producer surplus values for commercial fishing ranges from 50 to 90 percent of the market value. In assessments of Great Lakes fisheries, an estimate of approximately 40% has been derived as the relationship between gross revenues and the surplus of commercial fishermen (Cleland and Bishop, 1984, Bishop, personal communication, 2002). For the purposes of this study, EPA believes producer surplus to watermen is probably in the range of 40% to 70% of dockside landings values.

Producer surplus is one portion of the total economic surplus impacted by increased commercial stocks — the total benefits are comprised of the economic surplus to producers, wholesalers, processors, retailers, and consumers. Primary empirical research deriving “multi-market” welfare measures for commercial fisheries have estimated that surplus accruing to commercial anglers amount to approximately 22% of the total surplus accruing to watermen, retailers and consumers combined (Norton et al., 1983; Holt and Bishop, 2002). Thus, total economic surplus across the relevant commercial fisheries multi-tiered markets can be estimated as approximately 4.5 times greater than producer surplus alone (given that producer

surplus is roughly 22% of the total surplus generated). This relationship is applied in the case studies to estimate total surplus from the projected changes in commercial landings.

Applying this method, estimates of the economic loss to commercial fisheries resulting from I&E at Seabrook range from $1,800 to $3,100 per year for impingement and from $21,000 to $36,700 per year for entrainment. For I&E at Pilgrim, estimates range from $900 to $1,600 per year for impingement and from $56,000 to $98,000 per year for entrainment.

G4-4 Economic Value of Forage Fish Losses

Many species affected by I&E are not commercially or recreationally fished. For the purposes in this study, EPA referred to these species as forage fish. Forage fish are species that are prey for other species and are important components of aquatic food webs. Based on the analysis of I&E data presented in Chapter G3, Table G4-15 summarizes impingement losses of forage species at Seabrook and Table G4-16 summaries entrainment losses. Impingement of forage species at Pilgrim is summarized in Table G4-17 and entrainment losses are summarized in Table G4-18. The following sections discuss the economic valuation of these losses using two alternative valuation methods.

Table G4-15: Summary of Seabrook's Mean Annual Impingement of Forage Species

Species	Impingement Count (#)	Age 1 Equivalents (#)	Production Foregone (lbs)
American sand lance	476	696	4
Fourbeard rockling	3	4	0
Grubby	1,156	1,418	86
Killifish striped	8	11	0
Lumpfish	391	428	14
Northern pipefish	285	388	0
Radiated shanny	20	24	0
Rock gunnel	710	864	4
Sculpin spp.	401	492	30
Threespine stickleback	171	243	0
Forage species total	3,621	4,568	138

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Table G4-16: Summary of Seabrook's Mean Annual Entrainment of Forage Species

Species	Impingement Count (#)	Age 1 Equivalents (#)	Production Foregone (lbs)
American sand lance	13,329,111	397,513	14,937
Fourbeard rockling	58,510,333	165,150	3,931
Grubby	14,012,778	252,098	24,840
Killifish striped	0	0	0
Lumpfish	31,862,889	5,014	24,655
Northern pipefish	11,111	782	30
Radiated shanny	1,700,222	144,945	480
Rock gunnel	22,719,111	3,217,922	35,278
Sculpin spp.	1,634,444	29,405	2,897
Threespine stickleback	0	0	0
Forage species total	143,779,999	4,212,828	107,049

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Table G4-17: Summary of Pilgrim's Mean Annual Impingement of Forage Species

Species	Impingement Count (#)	Age 1 Equivalents (#)	Production Foregone (lbs)
American sand lance	19	27	0
Bay anchovy	11	18	0
Fourbeard rockling	2	2	0
Grubby	717	879	53
Hogchoker	2	2	0
Killifish striped	66	90	1
Lumpfish	198	217	7
Northern pipefish	87	118	0
Radiated shanny	45	54	0
Rock gunnel	63	77	0
Sculpin spp.	11	13	1
Threespine stickleback	83	118	0
Total	1,304	1,616	63

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Table G4-18: Summary Pilgrim's Mean Annual Entrainment of Forage Species			
Species	**Entrainment Count (#)**	**Age 1 Equivalents (#)**	**Production Foregone (lbs)**
American sand lance	138,023,372	4,116,258	87,207
Fourbeard rockling	94,252,169	411,189	1,809
Lumpfish	6,489,657	1,080	5,205
Radiated shanny	19,289,027	1,644,402	5,053
Rock gunnel	34,332,210	4,862,795	37,245
Sculpin spp.	40,841,427	734,760	40,814
Total	333,227,862	11,770,483	177,333

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G4-4.1 Replacement Cost of Fish

The replacement value of fish can be used in several instances. First, if a fish kill of a fishery species is mitigated by stocking of hatchery fish, then losses to the commercial and recreational fisheries would be reduced, but fish replacement costs would still be incurred and should be accounted for. Second, if the fish are not caught in the commercial or recreational fishery, but are important as forage or bait, the replacement value can be used as a lower bound estimate of their value (it is a lower bound because it would not consider how reduction in their stock may affect other species' stocks). Third, where there are not enough data to allow calculation of value losses to the recreational and commercial fisheries, replacement cost can be used as a proxy for lost fishery values. Typically the consumer or producer surplus is greater than fish replacement costs, and replacement costs typically omit problems associated with restocking programs (e.g., limiting genetic diversity).

The cost of replacing forage fish lost to I&E has two main components. The first component is the cost of raising the replacement fish. Tables G4-19 and G4-20 display the replacement costs of some of the forage fish species known to be impinged or entrained at Seabrook or Pilgrim. The costs are average costs to fish hatcheries across North America to produce different species of fish for stocking (AFS, 1993). The second component of replacement cost is the transportation cost, which includes costs associated with vehicles, personnel, fuel, water, chemicals, containers, and nets. The AFS (1993) estimates these costs at approximately $1.13 per mile, but does not indicate how many fish (or how many pounds of fish) are transported for this price. Lacking relevant data, EPA did not include the transportation costs in this valuation approach.

Tables G4-19 and G4-20 also presents the computed values of the annual average forage replacement cost losses at the two facilities. The value of forage losses at Seabrook using the replacement cost method is $20 per year for impingement and $5,600 per year for entrainment. Forage losses at Pilgrim are valued at $90 per year for impingement and $30,900 per year for entrainment.

Table G4-19: Replacement Cost of Various Forage Fish Species at the Seabrook Facility.			
Species	**Hatchery Costs [a, b] ($/lb)**	**Annual Cost of Replacing Forage Losses ($2000)**	
		Impingement	**Entrainment**
American sand lance	0.34	$1	$633
Fourbeard rockling	0.34	$0	$226
Grubby	0.34	$2	$346
Lumpfish	0.34	$2	$25
Northern pipefish	0.34	$1	$2
Radiated shanny	0.34	$0	$31
Rainbow smelt	0.34	$12	$94
Rock gunnel	0.34	$1	$4,181
Sculpin spp.	0.34	$1	$40
Total		$20	$5,580

[a] Values are from AFS (1993). These costs use the average value for all species listed in AFS (1993) since the species listed are not included in AFS (1993).

[b] These values were inflated to $2000 from $1989, but this could be imprecise for current fish rearing and stocking costs.

ThuJan1711:32:33MST2002;TableD:lossinselectedforagespecies;Plant:seabrook.90.98;type:IPathname:P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableD.forage.eco.ter.repl.seabrook.90.98.I.csv

Table G4-20: Replacement Cost of Various Forage Fish Species at the Pilgrim Facility.

Species	Hatchery Costs [a, b] ($/lb)	Annual Cost of Replacing Forage Losses ($2000)	
		Impingement	Entrainment
American sand lance	0.34	$0	$6,557
Fourbeard rockling	0.34	$0	$563
Grubby	0.34	$1	0
Lumpfish	0.34	$1	$5
Radiated shanny	0.34	$0	$348
Rainbow smelt	0.34	$85	$16,137
Rock gunnel	0.34	$0	$6,319
Sculpin spp.	0.34	$0	$1,010
Total		$88	$30,939

[a] Values are from AFS (1993). These costs use the average value for all species listed in AFS (1993) since the species listed are not included in AFS (1993).
[b] These values were inflated to $2000 from $1989, but this could be imprecise for current fish rearing and stocking costs.
ThuJan1710:34:23MST2002;TableD:lossinselectedforagespecies;Plant:pilgrim.74.99;type:IPathname:P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/TableD.forage.eco.ter.repl.pilgrim.74.99.I.csv

G4-4.2 Production Foregone Value of Forage Fish

This approach considers the foregone production of commercial and recreational fishery species resulting from I&E of forage species based on estimates of trophic transfer efficiency, as discussed in Chapter A5 of Part A of this document. The economic valuation of forage losses is based on the dollar value of the foregone fishery yield resulting from these losses. Results for entrainment of forage species at Seabrook are presented in Table G4-21. Results for entrainment of forage species at Pilgrim are presented in Table G4-22. The values listed are obtained from converting the forage species into species that may be commercially or recreationally valued. The values range from $65,700 to $141,500 per year for entrainment at Seabrook. For Pilgrim, the values range from $25,400 to $33,300 per year for entrainment. Impingement values were negligible and thus are not discussed.

Note that the results using the production foregone approach indicate higher losses at Seabrook than at Pilgrim, even though the replacement cost approach yields the opposite finding. This reflects the differences in the approaches, wherein replacement costs reflect the number of fish lost, and the production foregone approach captures how the different mix of fish losses may alter recreational and commercial biomass.

Table G4-21: Mean Annual Value of Production Foregone of Fishery Species Resulting from Entrainment of Forage Species at Seabrook.

Species	Annual Loss in Production Foregone Value from Entrainment of Forage Species ($2000)	
	Low	High
Atlantic herring	$4	$7
Bluefish	$63,013	$137,347
Butterfish	$58	$112
Cod Atlantic	$331	$569
Cunner	$289	$347
Mackerel Atlantic	$39	$87
Menhaden Atlantic	$592	$1,035
Plaice American	$311	$544
Pollock	$0	$1
Rainbow smelt	$49	$111
Searobin	$266	$298
Tautog	$357	$518
Windowpane	$259	$388
Winter flounder	$122	$156
Total	$65,690	$141,520

Fri Feb 08 10:11:16 MST 2002 ; TableD: loss in selected forage species; Plant: seabrook.90.98 ; type: E Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableD.forage.eco.ter.repl.seabrook.90.98.E.csv

Table G4-22: Mean Annual Value of Production Foregone of Fishery Species Resulting from Entrainment of Forage Species at Pilgrim

Species	Annual Loss in Production Foregone Value from Entrainment of Forage Species ($2000)	
	Low	High
Atlantic cod	$549	$944
Atlantic mackerel	$1,421	$3,202
Cunner	$564	$679
Herring Atlantic	$568	$993
Menhaden Atlantic	$229	$401
Plaice American	$2,287	$4,003
Pollock	$161	$281
Rainbow smelt	$80	$181
Searobin	$15,895	$17,847
Silverside Atlantic	$16	$29
Tautog	$646	$936
Windowpane	$2	$4
Winter flounder	$2,968	$3,790
Total	$25,387	$33,288

Thu Feb 07 17:19:35 MST 2002 ; TableD: loss in selected forage species; Plant: pilgrim.74.99 ; type: E Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/TableD.forage.eco.ter.repl.pilgrim.74.99.E.csv

G4-5 Nonuse Values

Recreational consumer surplus and commercial impacts are only part of the total losses that the public realizes from I&E impacts on fisheries. Nonuse or passive use impacts arise when individuals value environmental changes apart from any past, present, or anticipated future use of the resource in question. Such passive use values have been categorized in several ways in the economic literature, typically embracing the concepts of existence (stewardship) and bequest (intergenerational equity) motives. Using a "rule of thumb" that nonuse impacts are at least equivalent to 50 percent of the recreational use impact (see Chapter A9 in Part A of this document for further discussion), EPA estimated nonuse values for baseline losses at Seabrook, to range from $500 to $600 per year for impingement and from $37,500 to $43,600 per year for entrainment. At Pilgrim, nonuse values for baseline losses range from $700 to $1,100 per year for impingement and from $143,900 to $204,400 per year for entrainment.

G4-6 Summary of Mean Annual Economic Value of I&E at Seabrook and Pilgrim

Tables G4-23 and G4-24 summarize the economic values associated with mean annual I&E at the Seabrook and Pilgrim facilities. Total impacts at Seabrook range from $3,400 to $5,100 per year for impingement and from $139,100 to $309,100 per year for entrainment. Total impacts at Pilgrim range from $3,200 to $4,900 per year for impingement and from $513,200 to $744,400 per year for entrainment.

Table G4-23: Summary of Economic Valuation of Mean Annual I&E at Seabrook Facility ($2000).

		Impingement	Entrainment	Total
Commercial: Total Surplus (Direct Use, Market)	Low	$1,778	$20,985	$22,763
	High	$3,112	$36,724	$39,836
Recreational (Direct Use, Nonmarket)	Low	$1,083	$75,036	$76,119
	High	$1,295	$87,209	$88,504
Nonuse (Passive Use, Nonmarket)	Low	$542	$37,518	$38,060
	High	$647	$43,605	$44,252
Forage (Indirect Use, Nonmarket)				
Production Foregone	Low	NA	$65,690	$65,690
	High	NA	$141,520	$141,520
Replacement		$20	$5,580	$5,600
Total (Com + Rec + Nonuse + Forage)[a]	Low	$3,423	$139,119	$142,542
	High	$5,074	$309,058	$314,131

[a] In calculating the total low values, the lower of the two forage valuation methods (production foregone and replacement) was used and to calculate the total high values, the higher of the two forage valuation methods was used.
NA= Not included because values negligible.
Fri Feb 08 10:11:18 MST 2002 ; TableE.summary; Plant: seabrook.90.98 ; Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/TableE.summary.seabrook.90.98.csv

Table G4-24: Summary of Economic Valuation of Mean Annual I&E at Pilgrim Facility ($2000).

		Impingement	Entrainment	Total
Commercial: Total Surplus (Direct Use, Market)	Low	$940	$55,976	$56,916
	High	$1,646	$97,958	$99,603
Recreational (Direct Use, Nonmarket)	Low	$1,499	$287,897	$289,396
	High	$2,115	$408,755	$410,869
Nonuse (Passive Use, Nonmarket)	Low	$749	$143,949	$144,698
	High	$1,057	$204,377	$205,435
Forage (Indirect Use, Nonmarket)				
Production Foregone	Low	NA	$25,387	$25,403
	High	NA	$33,288	$33,314
Replacement		$88	$30,939	$31,027
Total (Com + Rec + Nonuse + Forage)[a]	Low	$3,276	$513,209	$516,485
	High	$4,905	$744,377	$749,283

[a] In calculating the total low values, the lower of the two forage valuation methods (production foregone and replacement) was used and to calculate the total high values, the higher of the two forage valuation methods was used.
NA= Not included because values negligible.
Thu Feb 07 17:19:36 MST 2002 ; TableE.summary; Plant: pilgrim.74.99 ; Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/TableE.summary.pilgrim.74.99.csv